SHORT- AND LONG-PERIOD GRAVITY WAVES OVER NORTHEASTERN UNITED STATES *

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ABSTRACT

Short-period internal gravity waves recorded at Palisades, N.Y., have been found to associated with a rapidly moving pressure rise explained as a very long gravity wave. The speeds of propagation of both the pressure rise (long wave) and short-period gravity waves are nearly the same and although they show fairly good agreement with the theoretical propagation speed of long internal gravity waves, the problem is not regarded as fully solved.

A study of the movement of an intense pressure rise over New England presumed to be associated with gravity waves has been reported by Wagner [1]. A similar phenomenon was observed in northeastern United States on March 14–15, 1962.

An unusual group of high-amplitude and nearly sinusoidal pressure oscillations was recorded on the Lamont Geological Observatory network of microbarovariographs. Figure 1 shows the multipartite arrangement of this network and figure 2 shows the waves recorded at the four stations from 2100 to 2330 EST, March 14, 1962. The period of the oscillations is in the range of 4.5–5 min. Their speed and direction of propagation across the network, which were determined by the method of phase matching, ranged between 50 and 60 m./sec. from WNW to NW. The experimental error in determining the speed of propagation is ±5 m./sec. Because these oscillations are traceable with systematic time lags at each of the variograph stations, and moved with a speed much greater than that of the ambient wind, they must represent traveling waves. Such waves have been explained as internal gravity waves [2, 3, 4].

Figure 3 shows the surface synoptic pattern for 1900 EST which is about the time of onset of the waves. This macroscale presentation does not indicate any obvious feature related to their occurrence. At this time, New York City (shown by a cross), the nearest synoptic reporting station to Lamont, lay in the rear of an intense Low and just ahead of a flat high-pressure ridge. However, hourly observations of surface pressure and winds for New York City (fig. 4) showed an abrupt pressure rise of about 5 mb. in 3 hr. accompanied by a wind shift from westerly to northwesterly and an increase of wind

speed from 10 to 15 kt. at about the time of wave onset. Hourly wind and pressure data for other stations in northeastern United States showed similar pressure and wind observations.

An hour to hour analysis of meteorological data for a number of stations around New York City yields interesting results. One-hour pressure tendencies for 1600–1700, 1700–1800 and 1800–1900 EST are shown in figures 5, 6, and 7, respectively. An area of strong pressure rise traveled from the western border (fig. 5) to just north of Long Island (fig. 7). It is observed that the pressure rise moved from a westerly direction with a speed of about 60 m./sec. (about 120 kt.), which corresponds closely with the speed and direction of the 5-min.-period pressure waves detected by the Lamont network. We
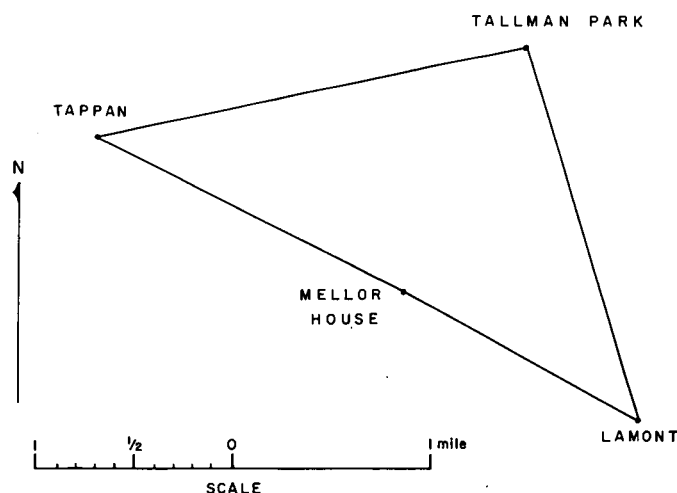

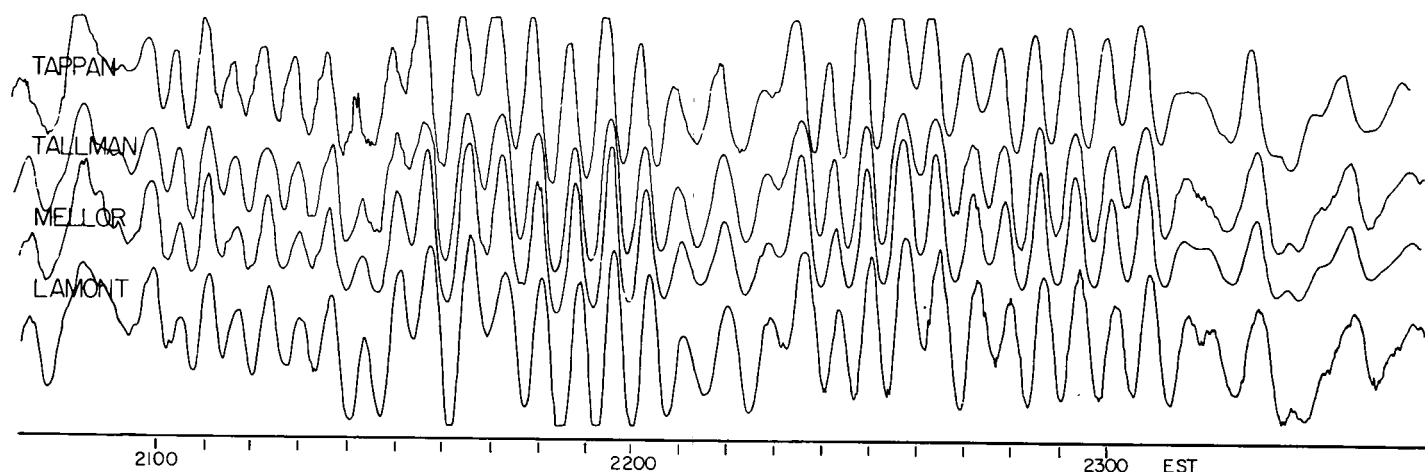FIGURE 1.—Multipartite network of the Lamont microbarovariographs.

FIGURE 2.—Short-period gravity waves recorded by the Lamont network on March 14, 1962. Times are EST. Maximum amplitudes are about 350 microbars.
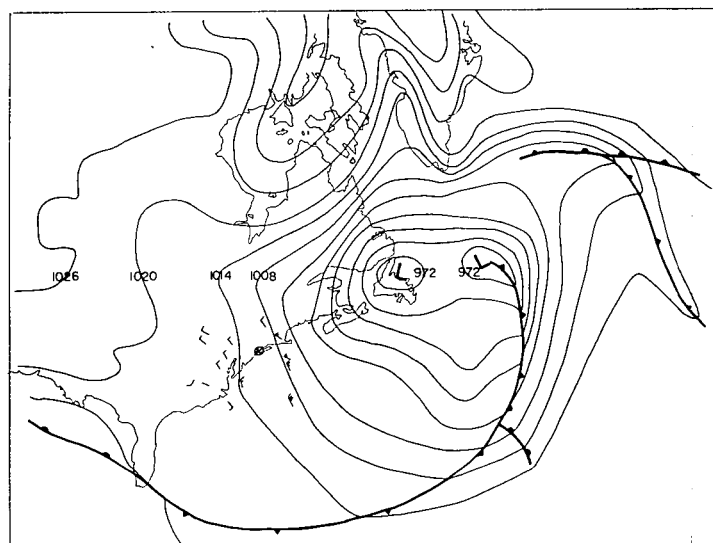

FIGURE 3.—Surface synoptic map for 1900 EST, March 14, 1962.

FIGURE 4.—Hourly pressure, temperature, and wind at New York City, March 14–15, 1962.

tentatively explain the short-period gravity waves recorded at Lamont as riding on a much longer-period wave which was itself a gravity wave, observed as a strong pressure rise on both weather maps and station pressure observations. Since the speed of travel of the pressure rise was much higher than the low-level wind speeds, it could not have been an advective feature. The wind change may have been due to the orbital motion associated with the waves, but since continuous wind data are not available to us, it is not possible to make any quantitative study. A continuous record of wind speed and direction would provide the evidence necessary to verify this proposition.

Assuming this disturbance to be a long gravity wave we have applied the two-layer solutions of both Namekawa [5] and Tepper [6]. The formula for observed phase speed for an incompressible atmosphere in the first solution is
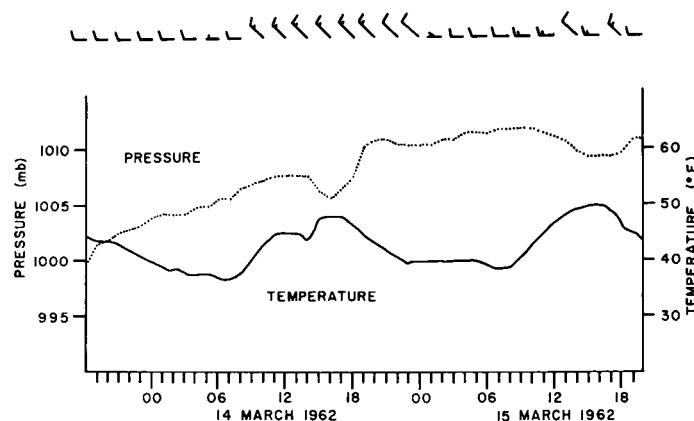
$$C = U + \sqrt{gh \frac{\Delta T}{T}}$$

where U is the average lower-layer wind speed; g, the acceleration of gravity; h, the height to the temperature discontinuity determining the surface of propagation; T, the absolute temperature at the discontinuity; and ΔT, the change in temperature across the discontinuity. The speed in this case is 49 m./sec., giving fair agreement with the observed speed in view of the approximations involved. The data used in this computation are shown in figure 8.

In the second solution using

$$C = U + \sqrt{\left(1 - \frac{\theta_1}{\theta_2}\right) gh}$$

for a compressible atmosphere, where θ_1 is the mean potential temperature of the lower layer and θ_2 that of the upper layer, we get a speed of 55 m./sec. Although
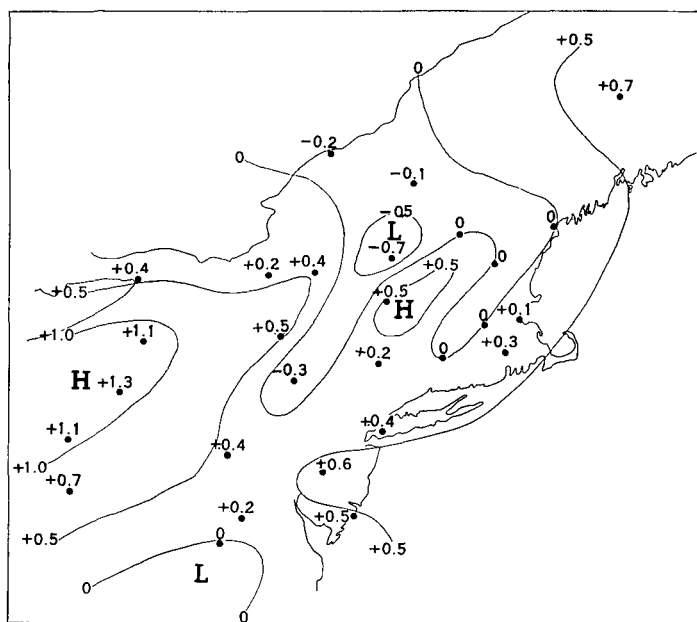
FIGURE 5.—Isallobar chart for 1600–1700 EST, March 14, 1962.
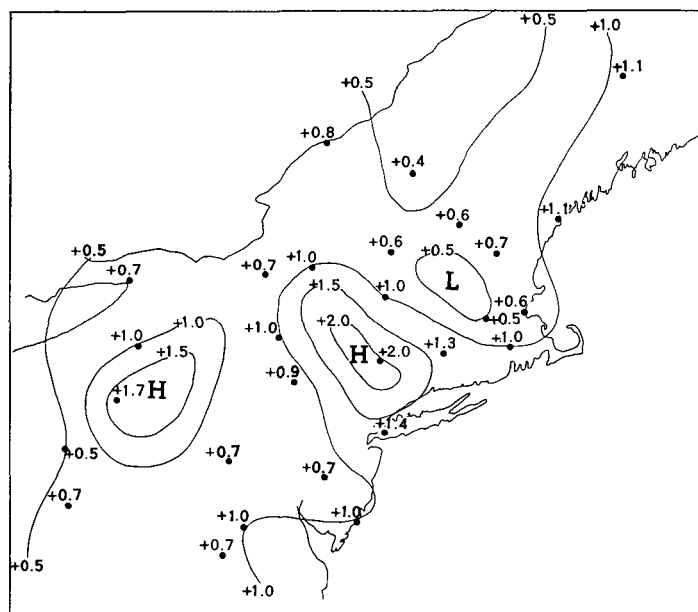

FIGURE 7.—Isallobar chart for 1800–1900 EST, March 14, 1962.
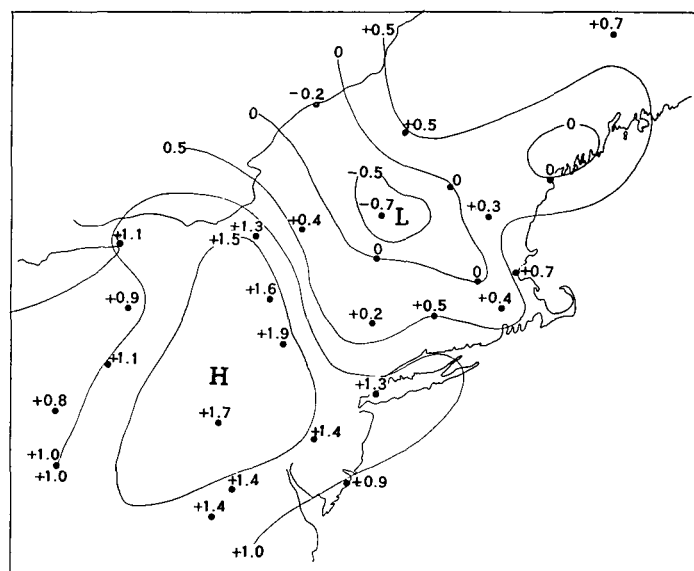

FIGURE 6.—Isallobar chart for 1700–1800 EST, March 14, 1962.

the two formulas are nearly equivalent the second solution gives somewhat better results in this case.

Admittedly the determination of observed velocity of the supposed long wave is not as accurate as that for the short-period waves recorded with much greater timing accuracy on the microbarobariograph network. We are therefore investigating this general problem by concentrating on the short-period internal waves. This study involves the comparison of theoretical with observed wave parameters using the vertical profiles of temperature and wind. The results of this comprehensive study will be published soon [7].
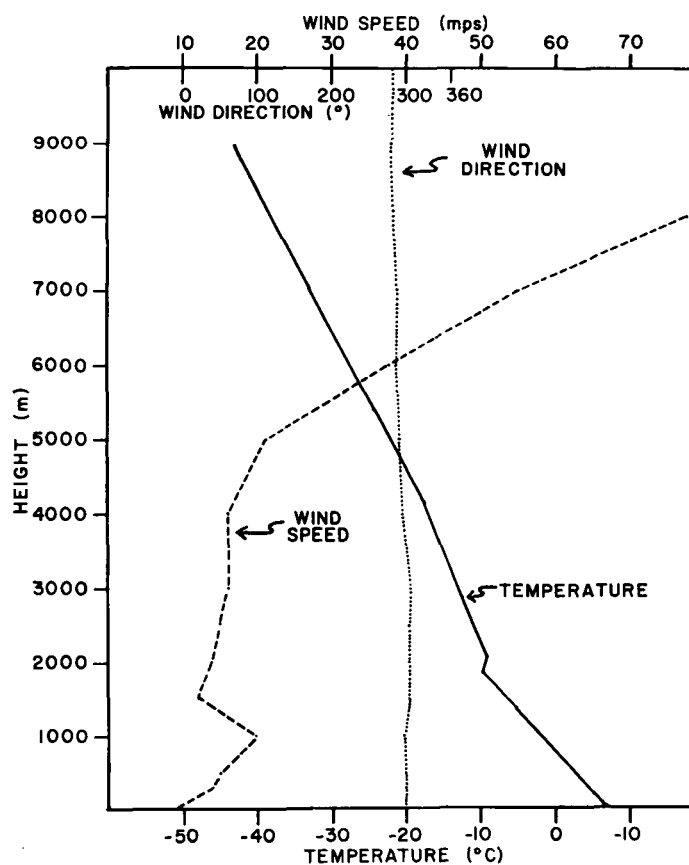

FIGURE 8.—Vertical profile of temperature and wind for 1900 EST, March 14, 1962 at Kennedy International Airport (Idlewild).

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